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# **SEMP Historical Meteorology Evaluation for the Area Near Fort Benning, GA: 1999 – 2001**

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## **Background**

The Strategic Environmental Research and Development Program (SERDP) has initiated a project focused on addressing science and technology requirements for ecosystem management of Department of Defense (DoD) military installations. This project, entitled the SERDP Ecosystem Management Project (SEMP), involves several research projects that are focused on the land management needs and goals of Fort Benning, GA. The goals of SEMP are to: (1) provide knowledge, tools and techniques to enhance sustainable mission use and stewardship of military installations, and (2) contribute to understanding and enhancing the ecological role of military installations within their ecoregions.

The two major components of SEMP are: (1) the creation of long-term monitoring site(s) on DoD lands to observe trends over

time, and (2) the establishment of research projects aimed at gaining a better understanding of the roles of DoD military mission activities and land management practices at various spatial (from plot to managed unit to installation-wide to regional and ecoregional) and temporal scales.

Five research efforts, and a long-term monitoring program, have been underway at Fort Benning, beginning in fiscal year (FY) 1999. They focus on identifying ecosystem change indicators and on understanding disturbance within the ecosystem; especially disturbances resulting from military mission activities and land management practices. Research teams from Oak Ridge National Laboratory, University of Florida, University of Georgia's Savannah River Research Laboratory, the Corps of Engineers Engineer Research and Development Center, and several other universities are

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14. ABSTRACT <b>The goals of SEMP (SERDP Ecosystem Management Project) are to: (1) provide knowledge, tools and techniques to enhance sustainable mission use and stewardship of military installations, and (2) contribute to understanding and enhancing the ecological role of military installations within their ecoregions. The objective of the research described in this technical note were to determine how aberrant the weather was during the first three SEMP data collection seasons, and suggest the possible effect that using the data from these years might have on the validity of SEMP-developed ecosystem models that propose to use the Study Years data as validation.</b>					
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working at Fort Benning, collaborating on strategies for selection of research sites, sharing common review forums, and contributing data into a common data repository.

During the 1999 and 2000 research seasons, a significant drought occurred. During the 2001 research season, a moderate drought occurred. At its worst, no water flowed in 9 out of 10 streams where SEMP water quality instruments had been installed. Since unusually dry seasons occurred during two of the three data collecting opportunities, the SERDP Science Advisory Board (SAB), in 2001, raised the question, “Are the data being collected representative of the local ecosystem?” A project designed to answer this question was budgeted in FY02 and initiated in October 2002.

A good deal of data had been collected in the first three seasons of the 10-year SEMP monitoring program, and this represented a majority of the data for several of the projects. Yet this was during a period that can be characterized as significantly more arid than normal.

## Objectives

1. Determine how aberrant the weather (temperature, precipitation, and stream flow) was during the first three SEMP data collection seasons (1999-2001 – the Study Years), and
2. Suggest the possible effect that using the data from these years might have on the validity of SEMP-developed ecosystem

models that propose to use the Study Years data as validation.

## Temperature

Air temperature is a basic climatic parameter. A summary for the West Central section of Georgia (see Appendix A for coverage) for Temperature for the period beginning in 1895 and continuing to 2003\* is presented in Figure 1 (p 8). For the Study Years, the average monthly temperatures were 50.5, 51.0, and 52.3 °F. These temperatures are 3.4, 3.9, and 5.2 degrees above the long-term average of 47.1 °F. These values are significantly above the average, showing a 3-year trend higher with the last 2 years above the first Root Mean Square (RMS) of the average temperature. They also may represent a portion of a larger trend (lasting 10 years) of above average temperatures that began roughly in the middle to late 1980s and has continued at the higher level since then. The Study Years are also unusual in that their averages were noticeably above the 10-year moving average (roughly 49.5 °F by +0.9, +1.4, and +1.7 degrees for 1999, 2000, and 2001, respectively). Therefore, all 3 years can be characterized as warm in a warm period. Following further along this line of thought, times of warmer and colder weather have occurred in lengths of roughly 16.5 years:

- Pre-1900 to 1915 {>15 years} cooler,
- 1915 to 1935 {20 years} warmer,

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\* Dataset compiled by Desert Research Institute Climate Center, [www.wrcc.dri.edu/spi/divplot/map.html](http://www.wrcc.dri.edu/spi/divplot/map.html) (no longer available)

- 1936 to 1944 {marginally or indistinctively 8 years} cooler,
- 1945-1962 {17 years} warmer,
- 1963-1984 {21 years} cooler.

The years 1999, 2000, and 2001 seem to represent the mature section of one of the warm phases.

We wished to ensure that the values from the Weather Service Office (WSO) location are representative of Fort Benning. To do this, we plotted (Figure 2, p 9) the 2000 WSO averages\* against the average of the SEMP values for our Meteorology Station 1<sup>†</sup> (located in roughly central Fort Benning; see Appendix C). The two values closely coincide with each other, so the regional averages appear to well represent Fort Benning parameters.

## Precipitation

Precipitation is another major climatic concern (Appendix A). A graph<sup>‡</sup> similar to that for temperature, and covering the same region (Figure 3, p 10), shows rainfall values of 38.6, 38.8, and 42.9 inches for 1999, 2000, 2001, respectively. The average of these data is 50.1 inches with an RMS of

\* <http://cirrus.dnr.state.sc.us/cgi-bin/sercc/cliMAIN.pl?ga2166>

<sup>†</sup> <http://sempdata.wes.army.mil/> SEMP values are taken every 30 minutes. Some months do not have complete data. January and February data are not available.

<sup>‡</sup> These data are called the Standardized Precipitation Index (SPI), a probability index that considers only precipitation. The SPI is based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. As the dry or wet conditions become more severe, the index becomes more negative or positive. From: <http://lwf.ncdc.noaa.gov/oa/climate/research/prelim/drought/spi.html>

7.5 inches. Thus, the Study Years 1999 and 2000 were much drier than average, the driest since 1954 when the last major drought in Georgia is recognized<sup>§</sup>. The year 2001 is also classed as a dry year. The years immediately preceding our Study Years tended to be wetter than usual, so the contrast in the minds of local individuals might be enhanced. The Study Years are not astoundingly unusual; single drought years of about 1 RMS have occurred 20 times previously. Significantly more extreme events have occurred in 1954 (dry) and 1929 (wet). In addition, 3 noteworthy drought years in a row (1895 to 1897) have occurred previously. Of these 3, 1 year was greater than and 2 years near the RMS value.) This suggests that even extended drought is within a normal pattern.

Stages in precipitation are more difficult to define than for temperature. Those that might be recognized are:

- 1900-1915 {15 years} dry,
- 1940-1950 {10 years} wet,
- 1960-1980 {20 years} wet,
- 1981-1989 {9 years} dry, and
- 1990-1997 {7 years} wet.

The average length for these stages is 12.2 years. Neither the stage length nor the years of a stage for precipitation coordinate with those for temperature. Therefore, precipitation and temperature stages appear to be independent. Finally, if the Study Years represent a part of a stage, they are only the initial part of a stage. If

<sup>§</sup> Telephone conversation 13 May 2003 with Pam Knox, Assistant Georgia State Climatologist, Driftmier Engineering Center, University of Georgia, Athens, GA, 706-542-6067.

they do not represent a part of a stage, then they represent only random climate fluctuation. More recent and supplemental data\* are presented in Figure 4 (p 11).

In Figure 4, an increasing precipitation deficit occurs from October 1998 to about June 2000. From July 2000 to June 2001, roughly average precipitation occurred. From July 2001 to April 2002 another deficit period took place. Average precipitation was experienced from May 2002 to January 2003.

We wish to know how unusual the Study Period is. From the WSO data (see Appendix C for location) for Columbus, we can compare the study period with the more than 50 years of data available (beginning in 1948 — Appendix B) (Figure 5, p 11).

From this figure, most of 1999-2001 has been a period of below average precipitation. To see if there was any difference between these data and those on Fort Benning, readings from one of the most central Meteorological Stations<sup>†</sup> for the year 2000 were summed by month and also displayed in Figure 4. It is apparent from Figure 4 that the WSO Columbus data well represent those taken in the middle of the installation (the light blue boxes vs. the smaller, darker blue boxes, respectively; in fact, one often overlaps the other).

\* From the Southeast Regional Climate Center: [http://water.dnr.state.sc.us/water/climate/sercc/products/cumulative\\_graphs/cumulative\\_map.html](http://water.dnr.state.sc.us/water/climate/sercc/products/cumulative_graphs/cumulative_map.html) (no longer available).

<sup>†</sup> All data available for SEMP Meteorological Station #1; data from the SEMP Data Repository for Climate for the year 2000. <http://sempdata.wes.army.mil/>. The installation itself does not collect this type of data.

The same data in Figure 4 were reformatted to show the degree of difference from the mean value for each month during the study period (Figure 5, p 11).

Table 1 can be derived from Figure 6 (p 12). The table shows that:

1. Most of 1999 was a deficit year at -0.81SD — nearly one standard deviation (except for October, which was normal). Thus, if 1SD represents 65% of the variation, a year like 1999 is still within roughly two-thirds of all years observed. (In fact, from Figure 2, previous severe years occurred in 1955 and 1905.)
2. Most of 2000 was a deficit year at -0.48SD — nearly one-half standard deviation (although several months were roughly normal).
3. Most of 2001 was a deficit year at -0.43SD — nearly as dry as the previous year, in spite of a huge positive peak in March.

**Table 1: Standard deviations for the Study Years**

Year	Average SD
1999	-0.811
2000	-0.485
2001	-0.433

As previously mentioned, this is unusual for the 50-year record for the Columbus Airport data, but over the longer period shown in Figure 3, it is characteristic. To better represent the climate, we further examine the longer period of available data from the West Central section of Georgia. In this exercise, the precipitation data are divided into nine “5-inch bins” covering the range of data from 30 inches as a low to 75 inches as a high. From this we can find the

frequency of occurrence of precipitation amounts in each bin (Table 2).

**Table 2: Frequency of Precipitation Ranges**

Bin No.	Bin Range	Count of Bin	Bin % Total	Cumulative Count
1	30-35	2	2	2
2	35-40	6	6	8
3	40-45	21	19	29
4	45-50	27	25	56
5	50-55	26	24	82
6	55-60	14	13	96
7	60-65	9	8	105
8	65-70	2	2	107
9	70-75	1	1	108

The years 1999 and 2000 (with 38.62 and 38.86 inches of precipitation, respectively) both fall in the 35-40 inches range (Bin Range 2 in Figure 7, p 12). Bin Range 2 can be expected to occur 5.5% of the time. Year 2001 (with 42.87 inches of precipitation) falls in the 40-45 inches range (Bin Range 3 in Figure 7), which can be expected to occur 19.4% of the time. Interestingly, none of these years fell into the lowest precipitation range. In regards to the occurrence of the Study Years being consecutive, similar low levels of precipitation previously occurred in 1896 and 1897 at 40.88 inches (falling into bin 2, which occurs 5.5% of the time) and 43.52 inches (falling in bin 3, which occurs 19.4% of the time). This coordinates directly with the official estimation that a drought like that during the Study Years occurs once every 50 to 100 years\*.

\* Knox, op cit.

## Stream Flow

The third parameter investigated was stream flow. The U.S. Geological Survey (USGS) has two stream monitoring stations near Fort Benning from which we might draw useful conclusions on the character of the climate during the Study Years. Monthly flow data for the Chattahoochee River is available beginning with 1929 (nearly 71 years of monthly averages are available), and for Upatoi Creek the record begins in 1968 (with about 34 years of monthly averages). A graph of the raw flow values by month was not informative because there was so much variation. To better interpret the flow data, the monthly averages were compared with the actual values for the Study Years (where they are available) for the Chattahoochee River (Figure 8, p 13) and Upatoi Creek<sup>†</sup> (Figure 9, p 13).

Comparing the Study Years with the average conditions for the USGS stations on the Chattahoochee (data for 1929-2000) and Upatoi Creek (data for 1968-2001), it can be seen that, although the absolute volumes are different, in both graphs the highest annual flow period centers on March of each year. The June to November segment corresponds to a steady, low flow period. From the Upatoi Creek data, flows for 2001 roughly reflect the average situation. Even in 1999 and 2000, the low flow period is not very different from

<sup>†</sup> Similar to the 2000 Benning curve in Figure 4, a review of the data available from the SEMP Data Repository for Hydrography was made to determine if there was any difference between these data and those on Fort Benning itself. Although the hydrography data have fields for flow rate and water level, no cross-section area is available, so it is not possible to compute flow from the SEMP hydrography data.

normal, particularly in Upatoi Creek. For both stations, however, 1999 and 2000 were well below average. This is almost entirely explained by the fact that the period of high flow for 1999 and 2000 were significantly lower than even a standard deviation. For both graphs, the peak flow period for 1999 and 2000 is barely distinguishable from the average low flow. This is a critical issue, since the yearly water flow budget (the sum of the area under the curves) is determined in the February to May period. For 1999 and 2000, the water flow budget was minimal at this important period.

The degree of deviation from the average flow rates for the rest of the year is presented in Figure 10 (p 14). It shows the variations to be strongly and consistently negative. The year 2000 is the consistently most low flow aberrant year, although 1999 is at times more aberrant. The March value for 1999 is 2.6SD away from the average for that month. Most significantly, the greatest negative deviation is in the most critical months for both years. There have been 10 occurrences of a greater standard deviation in 33 years, though March 1999 is at the 97th percentile.

## Conclusions

Precipitation has been more than one sigma below average for all three initial collection seasons. On time scales in the range of decades to a century, one sigma is not beyond the nature of the climate in the area. However, the first years of SEMP data gathering have captured a noteworthy dry period — one end of the spectrum.

For a program covering a temporal horizon of 25-30 years, it would appear this dry period is an expected, although an unusually extended, part of the variation in the system. However, the currently acquired SEMP data do not represent a full normal distribution.

From the data reviewed in this study, climatic variations may occur in temporal scales greater than 25-35 years. So the minimum scheduled SEMP temporal scale (10 years) may not be enough time to capture the full range of natural variability.

Where data were available (from the SEMP Data Repository), the values and trends were highly coincident when compared to the outside sources used here. There is every reason to believe that the regional data well represent Fort Benning weather characteristics.

The three Study Years appear to represent the drought portion of normal variation (i.e., it reaches, but does not significantly exceed, normal extremes). Ecosystems respond to forcing agents. A drought as a forcing agent is similar to forest fire as a forcing agent. In both cases, although they occur infrequently, they are nevertheless integral to the definition of an ecosystem. Researchers may actually consider themselves fortunate to have captured within their data one of the important events of the region's ecology. Similarly, the low stream flow rates observed (a reflection of low precipitation) are also ecosystem forcing events that help to define

the limits of what a system can endure and how the system sustains itself.

## Recommendations

1. Recognize in models being developed that the data collected thus far are likely to represent the drought portion of normal variation.
2. Data to test the variation resulting from an ecosystem model cannot be represented using solely data collected during the period 1999-2001.
3. To adequately capture the full range of expected fluctuation, the period of long-term data collection should be at least 25-35 years.

Although it is beyond the scope of this study, another question rises, “In the first 3 years of SEMP, efforts were focused on selecting environmental parameters to evaluate conditions over the longer life of the project. To what extent has the selection of these parameters been affected by the drought and what is the validity of the selected parameters in normal, let alone, extremely wet years?” As a logical next step then, an evaluation of the sensitivity of the SEMP parameters to climate variation needs to be carried out.

## Point of Contact

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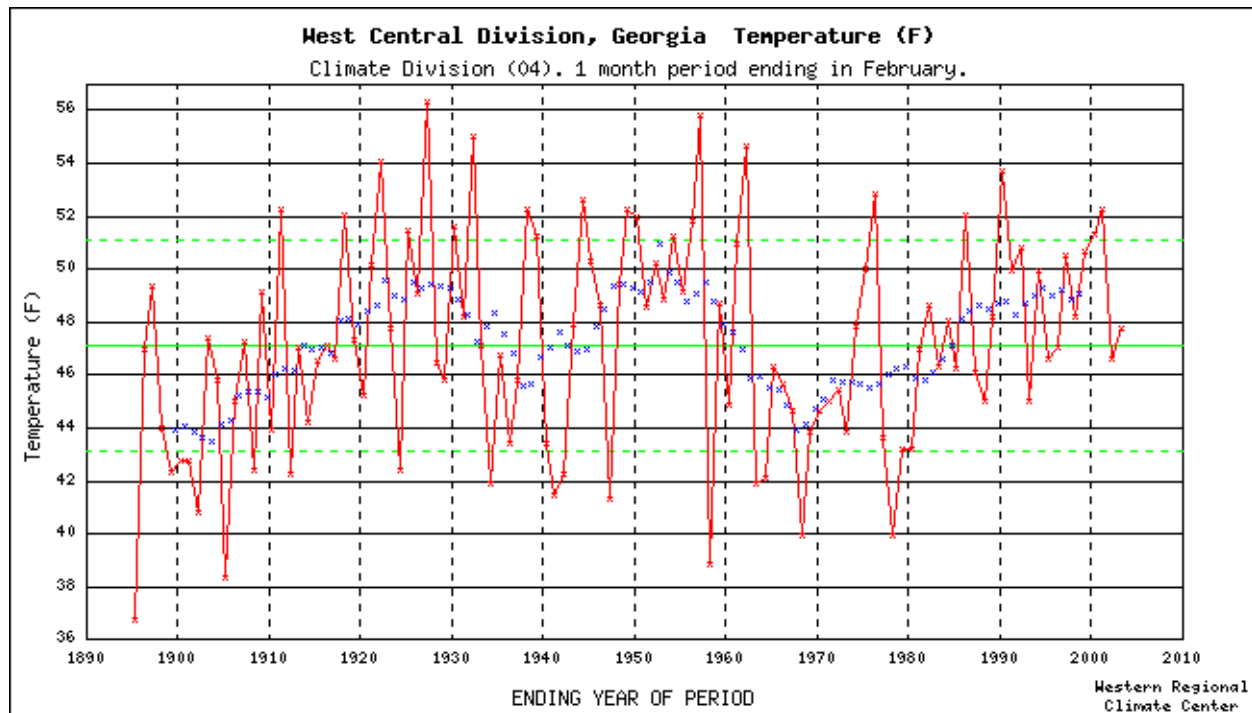
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- Southeast Regional Climate Center, Precipitation Accumulation and Departures from Normal in the Southeast at: [http://water.dnr.state.sc.us/water/climate/sercc/products/cumulative\\_graphs/cumulative\\_map.html](http://water.dnr.state.sc.us/water/climate/sercc/products/cumulative_graphs/cumulative_map.html)
- United States Geologic Survey: *Monthly Streamflow Statistics for the Nation*, at: <http://waterdata.usgs.gov/nwis/monthly>



## Figures



**Figure 1. Temperature for the West Central section of Georgia.**

Red - 1-month period  
blue - 10 year running mean  
green - average (solid),  $\pm$  sigma (dashed)

Average Temperature      1-Month Period Ending in Month 2

YEARS: 1890 - 2010

AVERAGE      47.121

SIGMA (RMS)      3.991

COEFF OF VAR      0.085

SKEWNESS      -0.060

MEDIAN      47.000

MAXIMUM VALUE      56.300

MINIMUM VALUE      36.700

NUMBER OBS      109.

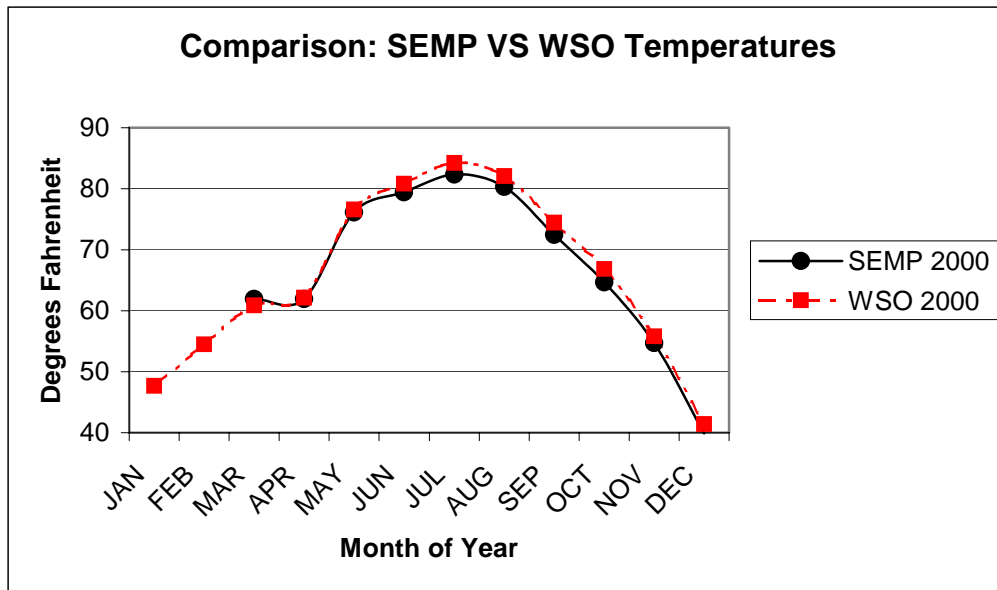
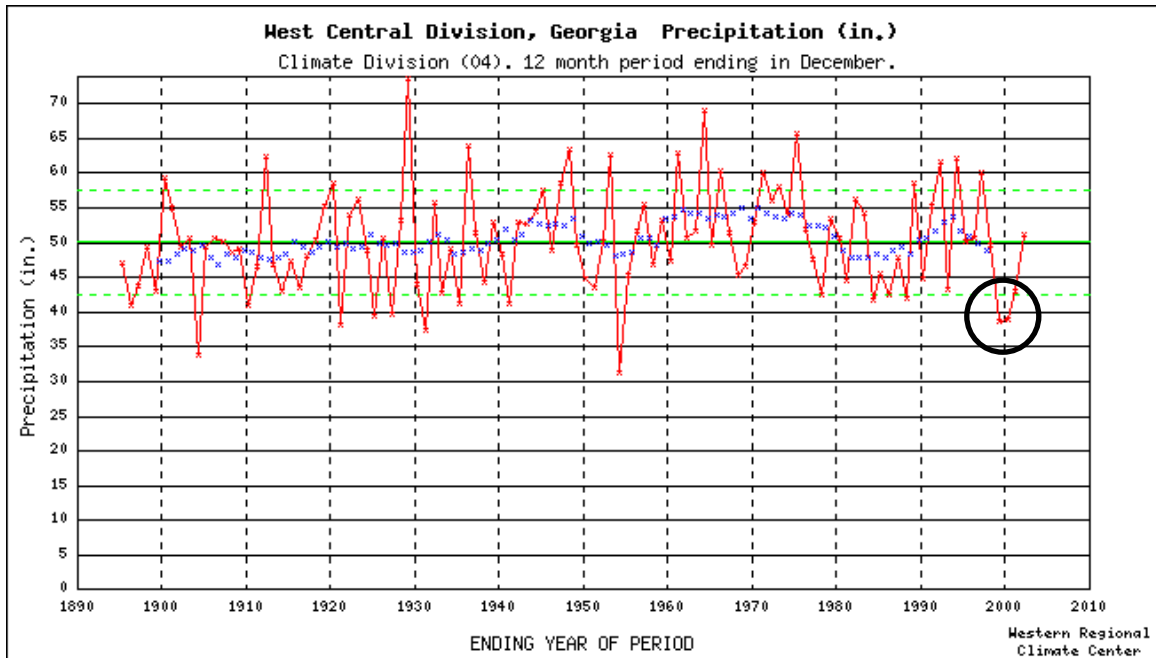


Figure 2. Comparison of SEMP and WSO monthly temperature averages.



**Figure 3: Precipitation for the West Central section of Georgia.**

Red - 12-month period

blue - 10 year running mean

green - average (solid),  $\pm$  sigma (dashed)

Total Precipitation 12-Month Period Ending in Month 12

YEARS: 1890 - 2010

AVERAGE 50.077

SIGMA (RMS) 7.496

COEFF OF VAR 0.150

SKEWNESS 0.335

MEDIAN 49.775

MAXIMUM VALUE 73.540

MINIMUM VALUE 31.030

NUMBER OBS 108.

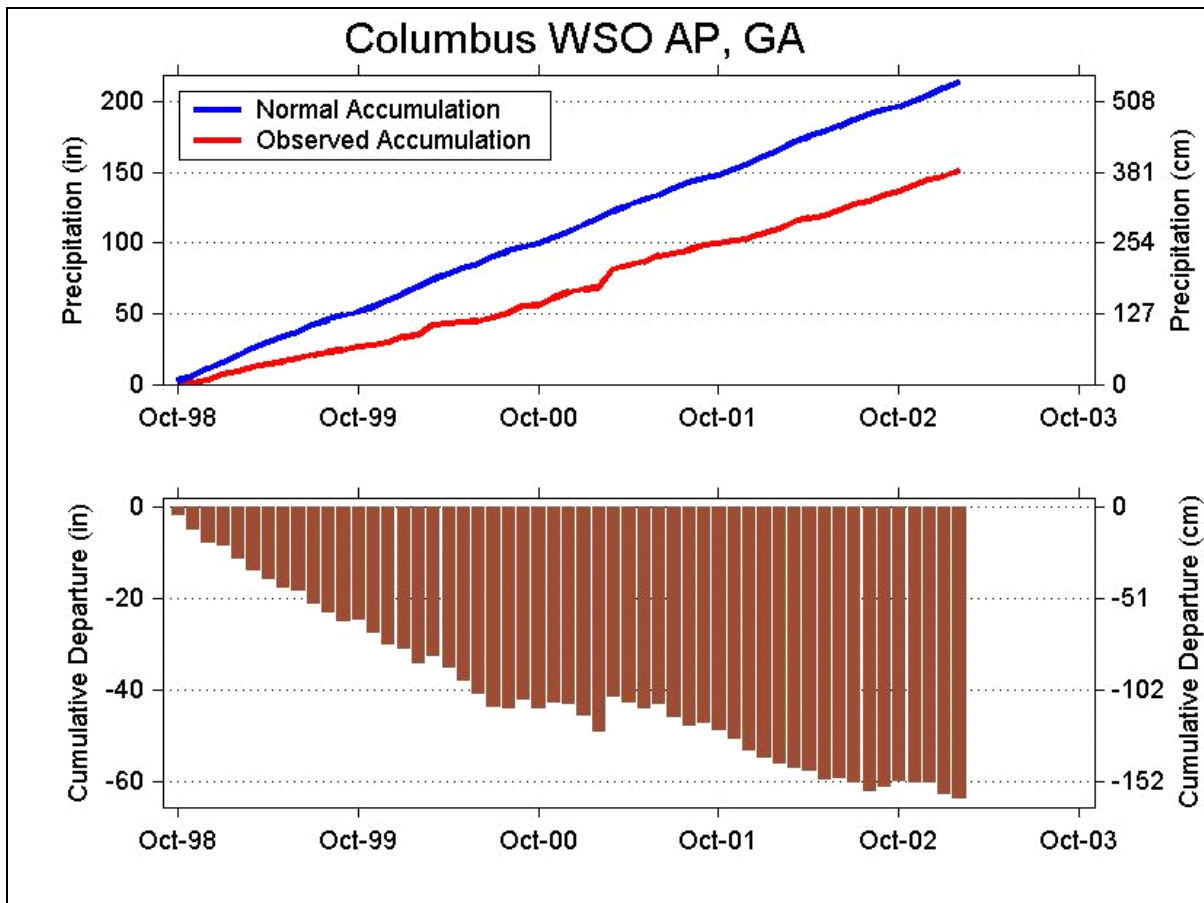


Figure 4. Precipitation at Columbus GA Airport and cumulative departure from October 1998.

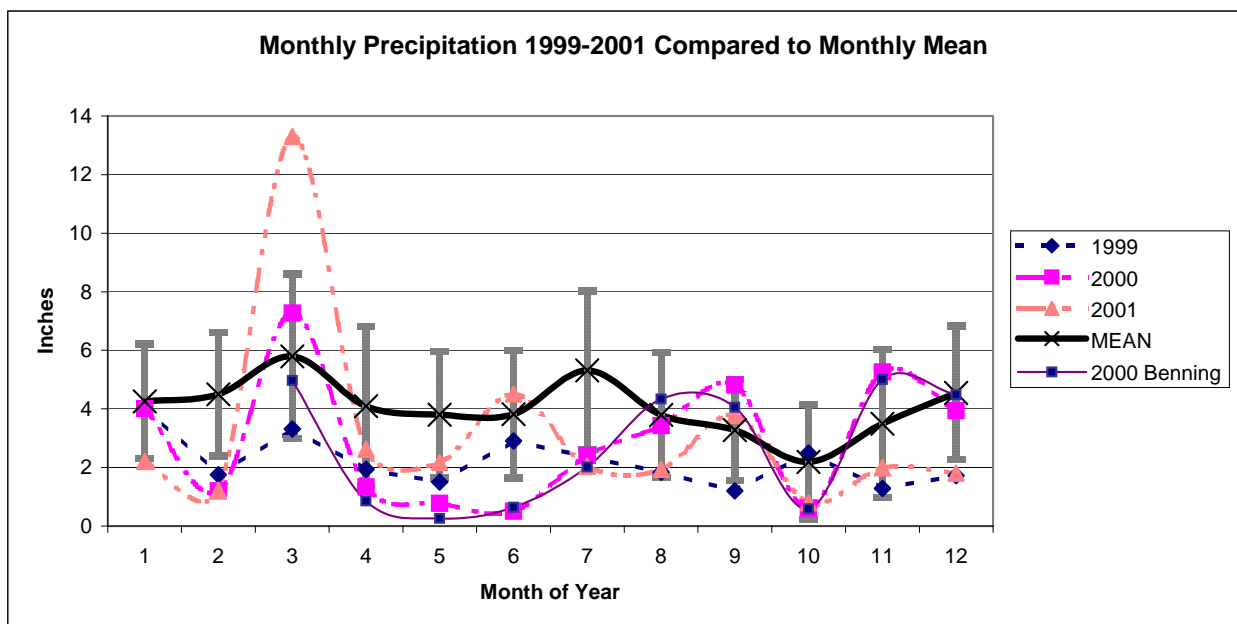


Figure 5. Average monthly precipitation compared to the Study Years.

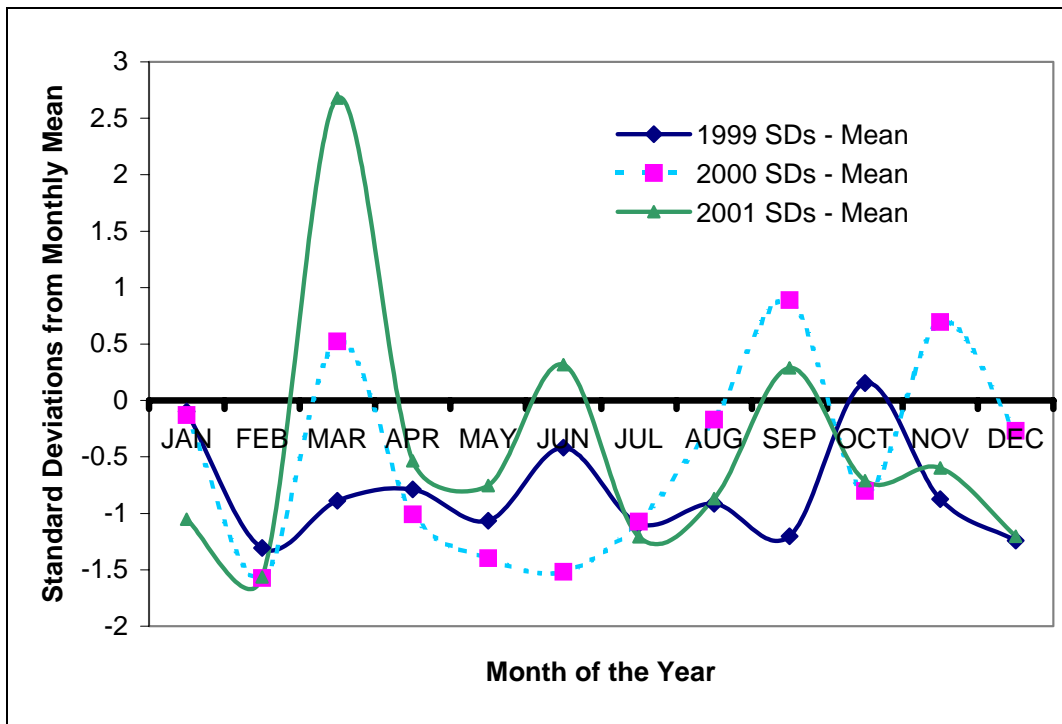


Figure 6. Precipitation difference from the mean value for each month during the study period.

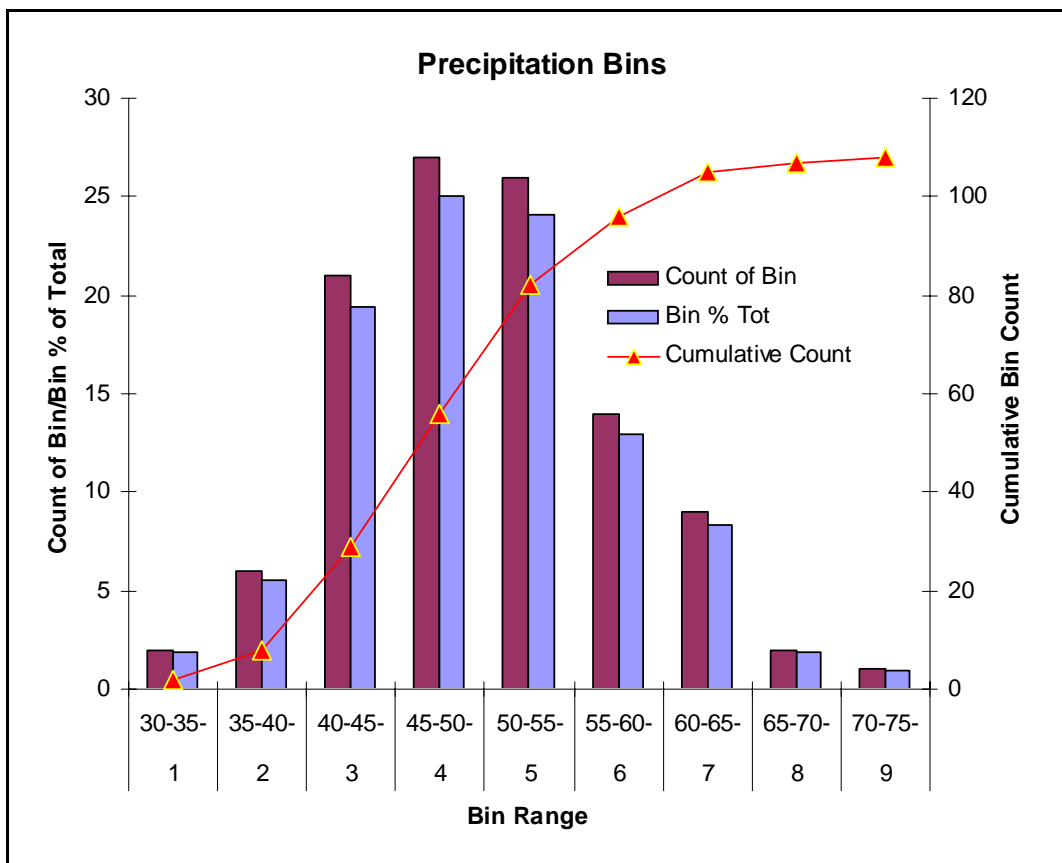


Figure 7. Frequency of precipitation ranges.

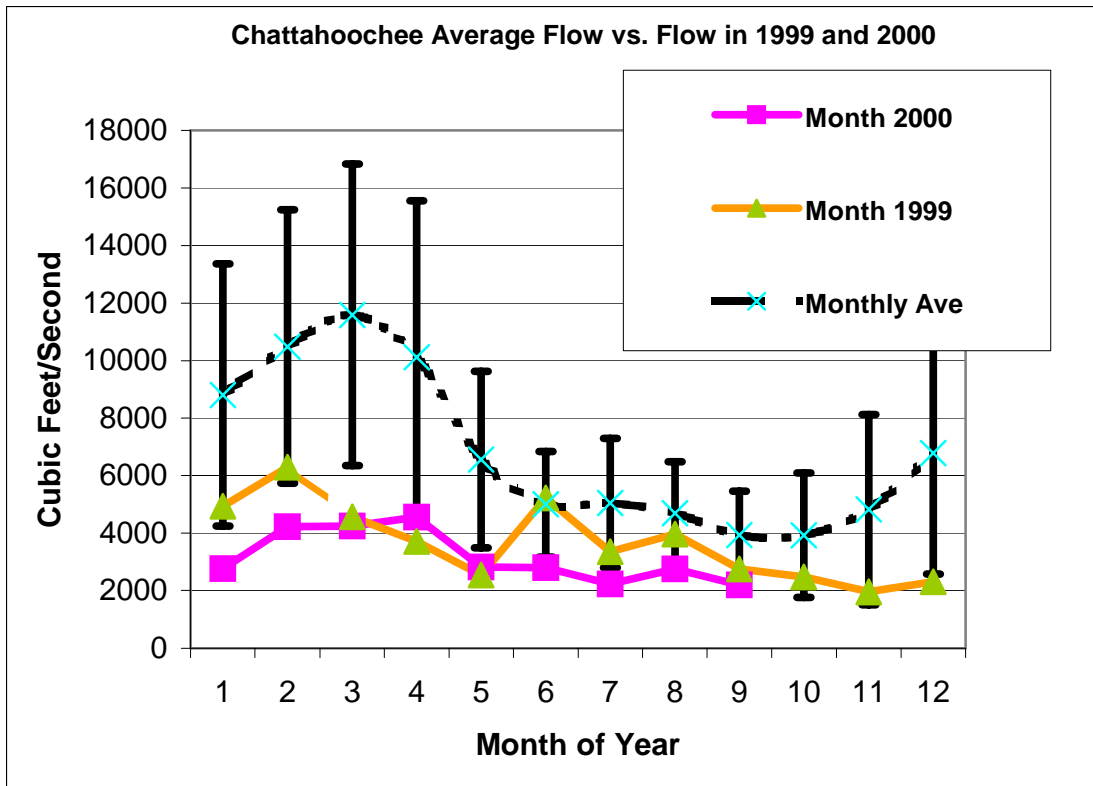


Figure 8. Study Years flow rates compared with average rates for Chattahoochee River.

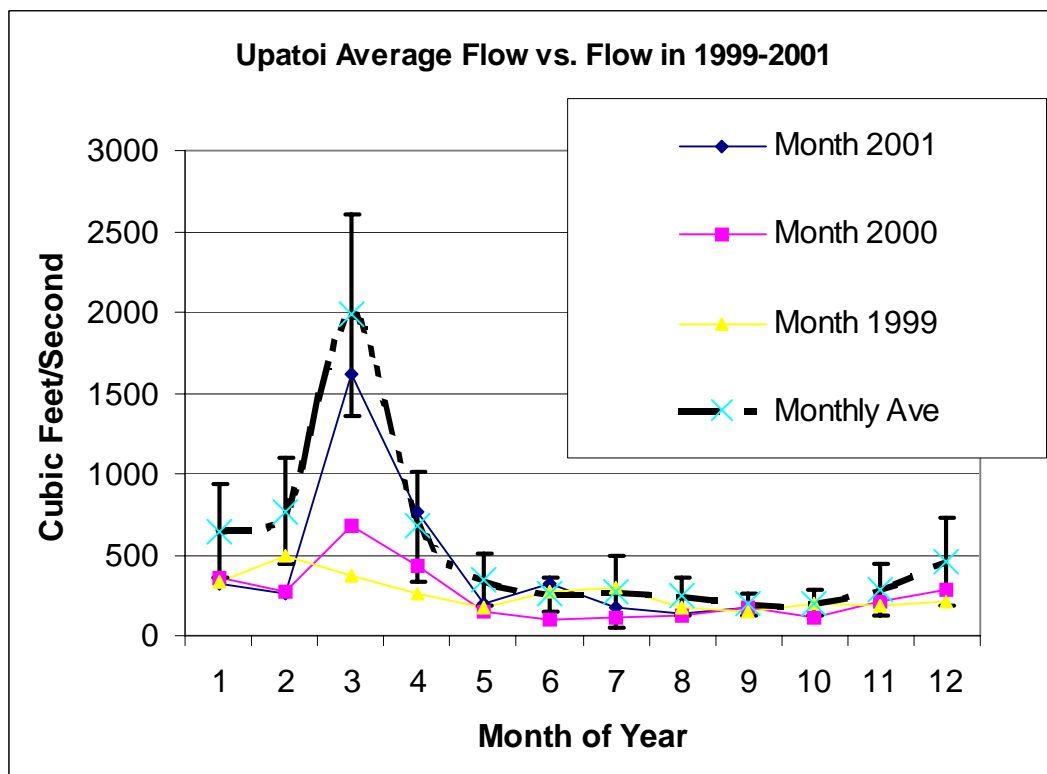
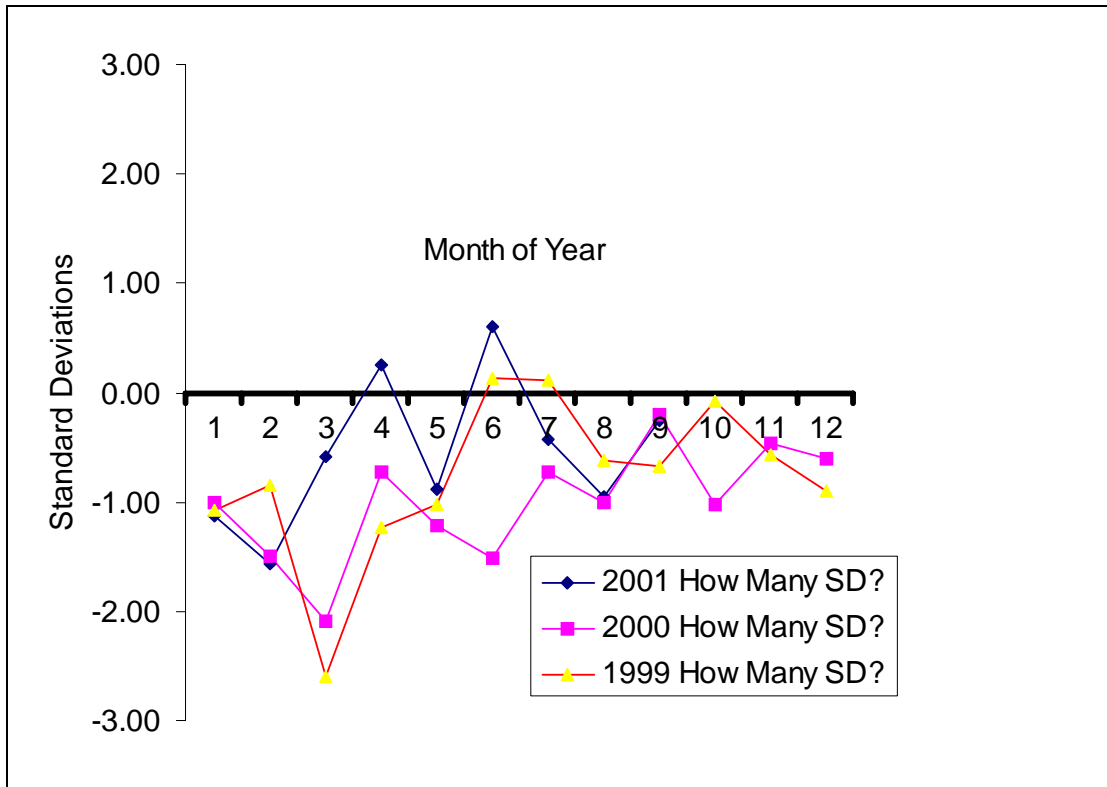


Figure 9. Study Years flow rates compared with average rates for Upatoi Creek.



**Figure 10. Difference from average flow in Upatoi Creek in standard deviations for the Study Years.**

## Appendix A: Data for West Central Section of Georgia for Precipitation

### Area of coverage:

Includes Haralson, Carroll, Douglas, Henry, Fayette, Coweta, Heard, Spalding, Meriwether, Troup, Lamar, Pike, Upson, Talbot, Harris, Taylor, Muscogee, Marion, Chattahoochee, Macon, and Schley counties in Georgia. See Figure A1.



**Figure A1: Darkened area is the extent of the West Central Georgia Division.**

		1937	51.270	1970	52.790
		1938	44.210	1971	60.050
		1939	52.780	1972	55.850
		1940	48.190	1973	57.810
		1941	41.190	1974	53.840
		1942	52.940	1975	65.650
		1943	52.620	1976	51.770
		1944	54.320	1977	47.380
		1945	57.440	1978	42.360
		1946	48.780	1979	53.260
		1947	58.390	1980	50.440
		1948	63.160	1981	44.470
		1949	49.460	1982	56.070
		1950	44.620	1983	54.070
		1951	43.430	1984	41.680
		1952	50.020	1985	45.450
		1953	62.530	1986	42.410
		1954	31.030	1987	47.590
		1955	45.140	1988	41.760
		1956	51.570	1989	58.560
		1957	55.340	1990	44.760
		1958	46.660	1991	55.070
		1959	53.170	1992	61.400
		1960	47.120	1993	43.000
		1961	62.670	1994	61.900
		1962	50.630	1995	49.990
		1963	51.600	1996	50.560
		1964	68.890	1997	59.950
		1965	49.400	1998	49.580
		1966	60.340	1999	38.620
		1967	51.270	2000	38.860
		1968	45.100	2001	42.870
		1969	46.330	2002	51.010
Year	Precipitation				
	(Inches)				
Average	50.1				
1895	46.830	1905	49.260		
1896	40.880	1906	50.570		
1897	43.520	1907	49.970		
1898	49.150	1908	48.430		
1899	42.910	1909	49.120		
1900	59.170	1910	40.820		
1901	54.870	1911	46.510		
1902	49.270	1912	62.350		
1903	50.500	1913	46.640		
1904	33.690	1914	42.770		
		1915	47.110		
		1916	43.280		
		1917	48.040		
		1918	50.180		
		1919	55.230		
		1920	58.560		
		1921	37.990		
		1922	53.830		
		1923	56.040		
		1924	48.800		
		1925	39.310		
		1926	50.650		
		1927	39.590		
		1928	53.140		
		1929	73.540		
		1930	44.000		
		1931	37.280		
		1932	55.650		
		1933	42.490		
		1934	49.050		
		1935	41.170		
		1936	63.680		

The stations included in the divisional averages are those that have long-term means calculated in the publication "Climatological Data" and also give departures from average. Many are non-airport stations. To derive the composite value, simple arithmetic averages of all stations are used. Typically this is a couple to a few dozen sites.



## Appendix B: WSO Data for Columbus (rainfall in inches/time unit)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1948	4.26	4.5	5.8	4.09	3.8	3.82	9.88	5.66	3.3	1.52	12.45	4.75	37.56
1949	2.87	7.79	3.86	8.12	3.03	3.32	10.41	4.31	3.14	2.83	1.34	3.84	54.86
1950	2.09	3.06	6.58	2.87	4.09	4.33	6.2	5.77	1.6	1.49	0.81	5.47	44.36
1951	2.06	1.22	3.72	3.66	1.58	5.43	3.99	5.37	6.94	1.24	2.52	5.65	43.38
1952	3.75	4.85	12.53	2.24	7.03	3.14	1.83	6.39	3.39	0.31	2.02	7.26	54.74
1953	4.75	6.6	1.9	11.67	4.36	4.9	6.09	1	5.98	0.3	2.11	9.39	59.05
1954	0.87	2.33	4.42	2.08	2.26	1.56	6.14	2.3	0.45	0.89	3.65	3.28	30.23
1955	4.93	4.02	2.08	4.34	6.21	1.29	12.15	2.08	0.42	1.73	2.58	0.43	42.26
1956	1.43	6.02	5.59	2.36	0.78	2.71	6.41	0.96	6.59	1.33	0.31	9.29	43.78
1957	3.05	1.97	4.24	6.19	7.63	4.29	1.74	2.61	3.88	1.05	8.62	1.91	47.18
1958	2.75	3.81	7.69	4.49	2.12	4.96	5.77	3.39	2.2	1.11	1.61	3.4	43.3
1959	3.87	6.16	8.12	1.41	8.45	6.16	5.01	4.17	3.31	6.59	0.89	2.29	56.43
1960	6.37	4.87	7.22	5.9	2.12	2.2	3.42	5.59	2.83	1.13	1.06	2.19	44.9
1961	2.34	9.41	6.54	5.36	3.93	4.32	4.53	4.96	1.17	0.02	1.11	7.29	50.98
1962	5.94	4.74	8.5	5.58	0.22	2.59	7.51	2.82	3.24	1.44	4.13	2.69	49.4
1963	6.24	3.25	2.69	2.53	1.17	4.3	3.2	3.04	3.04	0	4.8	4.88	39.14
1964	7.01	5.37	5.56	11.38	3.63	3.91	9.57	5.18	4.8	8.09	2.08	6.64	73.22
1965	2.79	5.46	6.06	1.07	2.54	7.91	5.48	1.88	5.81	2.99	2.13	2.75	46.87
1966	7.87	8.45	7.3	2.76	7.87	4.54	5.1	7.16	3.46	4.7	3.98	6.74	69.93
1967	3.48	3.34	1.4	0.86	6.62	10.83	3.81	5.06	3.84	3.23	2.86	4.9	50.23
1968	1.78	1.54	4.38	2.58	4.73	1.8	3.02	3.64	2.57	0.85	4.34	4.88	36.11
1969	1.22	4.13	4.49	8.3	6.02	2.81	6.55	2.93	6.32	0.31	0.79	5.09	48.96
1970	4.59	4.22	6.85	2.91	4.24	5.35	6.36	2.91	2.94	4.47	2.48	6.89	54.21
1971	5.33	7.13	9.16	3.27	4.42	4.22	13.24	5.11	4.96	0.26	2.41	4.96	64.47
1972	6.1	3.92	5.01	1.07	3.31	7.74	7.75	1.04	2.47	2.31	4.36	9.38	54.46
1973	6.03	4.55	9.82	5.95	4.53	4.42	3.64	6.97	2.23	1.16	3.37	7.14	59.81
1974	7.5	3.98	2.13	5.85	7.54	2.87	5.26	5.2	4.87	0.55	3.88	5.15	54.78
1975	6.64	7.56	7.32	6.66	4.78	3.94	7.87	4.11	2.85	5.42	2.67	3.54	63.36
1976	3.64	1.59	7.88	2.7	3.75	6.88	2.73	3.71	4.97	5.06	4.94	3.87	51.72
1977	4.15	2.02	7.92	1.73	3.49	3.46	3.79	10.07	3.54	2.15	6.12	3.56	52
1978	8.35	1.77	4.43	4.32	6.46	2.44	5.14	3.97	0.72	0.02	2.91	3.01	43.54
1979	6.91	7.84	2.72	10.69	4.59	1.24	4.12	2.5	5.5	1.47	4.52	2.52	54.62
1980	3.98	3.53	11.2	5.13	6.9	2.69	3.22	4.49	2.32	1.92	1.77	1.66	48.81
1981	1.27	7.72	4.2	6.88	1.45	3.05	5.4	2.93	2.62	1.9	1.18	8.94	47.54
1982	4.22	4.88	2.17	8.42	4.19	2.46	5.73	2.4	1.12	2	5.29	8.74	51.62
1983	3.95	5.75	7.37	4.48	2.02	5.05	3.57	3.16	6.01	1.82	5.07	7.02	55.27
1984	3.6	3.22	5.96	2.16	4.42	1.96	7.5	3.5	0.22	0.42	2.47	2.69	38.12
1985	3.84	6.21	1.38	1.9	4.86	2.03	4.53	3.28	0.98	2.85	2.94	4.85	39.65
1986	1.45	4.67	8.78	0.1	2.55	0.83	3.15	3.37	3.62	3.94	9.85	2.65	44.96
1987	5.47	7.69	4.38	0.62	6.25	9.19	4.31	1.82	2.31	0.37	3.22	2.9	48.53
1988	6.72	2.73	3.35	4.64	1.61	0.94	4.91	0.8	4.25	1.52	3.63	3.72	38.82
1989	0.72	2.64	4.88	6.51	2.42	7.34	11.58	2.27	3.68	2.46	5.11	7.31	56.92
1990	4.45	6.31	9.4	2.64	4.45	1.05	3.58	1.68	0.54	3	1.64	2.76	41.5
1991	7.46	1.94	7.86	4.32	7	3.9	3.79	10.11	2.38	0.58	4.7	3.34	57.38

<b>YEAR</b>	<b>JAN</b>	<b>FEB</b>	<b>MAR</b>	<b>APR</b>	<b>MAY</b>	<b>JUN</b>	<b>JUL</b>	<b>AUG</b>	<b>SEP</b>	<b>OCT</b>	<b>NOV</b>	<b>DEC</b>	<b>ANN</b>
1992	6.65	5.07	4.72	2.59	0.8	2.76	8.28	9.15	2.79	2.46	11.63	3.95	60.85
1993	4.12	3.52	8.06	2.21	2.04	0.74	3.41	4.32	0.97	3.72	4.92	4.01	42.04
1994	4.36	4.73	6.24	1.61	2.84	5.07	7.98	3.43	3.46	5.41	2.08	2.08	49.29
1995	3.91	6.05	2.68	1.32	1.51	3.46	2.34	2.24	3.7	8.41	3.75	5.45	44.82
1996	5.28	3.83	6.55	4.81	2.37	2.33	3.06	2.94	5.41	2.17	2.17	2.8	43.72
1997	4.16	6.29	1.86	5.84	4.65	5.99	4.4	1.73	2.25	2.77	4.26	6.72	50.92
1998	3.21	4.43	4.5	3.62	1.09	3.75	2.07	1.85	5.25	0.54	0.88	1.59	32.78
1999	4.07	1.76	3.31	1.94	1.5	2.91	2.36	1.84	1.2	2.49	1.29	1.72	26.39
2000	4.01	1.2	7.27	1.34	0.78	0.51	2.41	3.43	4.82	0.62	5.26	3.94	35.59
2001	2.21	1.22	13.3	2.63	2.17	4.51	2.05	1.94	3.78	0.8	1.99	1.81	38.41

Note: Data for stream flows are too extensive to be included in further appendices, but current values can be obtained at <http://waterdata.usgs.gov/nwis/monthly>.

## Appendix C: Location of Sites Mentioned in This Technical Note

